

“Escorting The Osprey; New Aircraft--Same Regiment”

CSC 1996

SUBJECT AREA Aviation

Executive Summary

Title: "Escorting The Osprey; New Aircraft -- Same Requirement"

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Problem: The V-22 Osprey, when flying in the Airplane mode of flight, is too fast to be escorted by the AH-1W. Fixed wing escort aircraft cannot provide for close proximity, immediate threat suppression.

Discussion: The V-22, while operating at high airspeeds in the fixed wing mode of flight is not supportable using present helicopter attached escort tactics. A proximity escort is necessary when the V-22 is operating in the fixed wing mode of flight due to airspeed and range differentials with supporting aircraft. When the V-22 is in approach to landing, or operating in the conversion mode of flight, an attached, direct fire capable escort is desired. This escort is necessary even with the planned incorporation of a self defensive weapon system. To use the higher airspeed and range capabilities of the V-22, an attached, armed escort with similar range, speed, and slow or hovering flight capabilities is necessary. Given the lack of such a platform at Initial Operational Capability of the V-22, new tactics need to be developed for escort of the V-22. Since the V-22 is an assault support aircraft, these escort tactics will drive tactics' development for all potential Medium Lift Missions.

Conclusion: A helicopter cannot provide adequate escort for the V-22 when it is operation in the airplane mode of flight. The V-22 can be escorted by detached and preemptive sweep fixed wing escort on the enroute portions of missions. When fixed wing escort is not available, only a heavily armed V-22 can provide that escort. The four bladed AH- 1W (4BW) can provide adequate sweep escort for the V-22 for low level missions of limited range. The 4BW can provide adequate attached escort from IP to LZ when the V-22 is operating in the helicopter mode of flight. New tactics must be developed using the entire range of capabilities of the V-22.

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CONTENTS

	<u>Page</u>
Executive Summary	ii
Contents	iii
List of Tables	v
List of Figures	vi
CHAPTER 1: FORWARD	1
CHAPTER 2: PURPOSE	3
Background	3
CHAPTER 3: THE ROLE OF ESCORT HELICOPTERS	5
US ARMY Escort Tactics/Utilization	5
USMC Escort Tactics/Utilization	7
USAF Escort Tactics/Utilization	10
Foreign Service Escort Tactics/Utilization	12
Conclusion	13
CHAPTER 4: DOES THE V-22 NEED AN ESCORT?	15
The Threat	15
Speed and Survivability	18
Self Defense	23
Conclusion	24
CHAPTER 5: ESCORT OPTIONS	25
What is a Compatible Escort?	25
What about the VMAO?	27
Will the 4BW be Compatible with V-22 Operations?	27
Why can't there be a Compatible Escort at V-22 IOC?	30
The AV-22?	30
Conclusion	31

	<u>Page</u>
CHAPTER 6: NEW TACTICAL EMPLOYMENT	32
Aren't sections better anyway?	32
High and Low Altitude Tactics	33
Additional Tactical Advancements	43
Conclusion	44
CHAPTER 7: COUNTER-ARGUMENT	45
CHAPTER 8: FURTHER RESEARCH REQUIREMENTS	46
Updated Studies and Analysis	46
Developmental/Operational Test Requirements	46
CHAPTER 9: CONCLUSION	47
What's the <u>BOTTOM LINE</u> ?	47
NOTES	48
BIBLIOGRAPHY	51

LIST OF TABLES

<u>TABLE</u>	<u>Page</u>
Table 4-1 -- Susceptability Altitudes and Airspeeds	20
Table 4-2 -- Aircraft Tracking Times in the HIGH Scenarios	20
Table 4-3 -- HIGH and LOW Scenario Comparison	21
Table 5-1 -- V-22, AH- 1/4BW Comparison	28

LIST OF FIGURES

<u>Figure</u>	<u>Page</u>
Figure 6-1 -- High Altitude Tactics (Penetration)	41
Figure 6-2 -- Low Altitude Tactics (Sections by Separate Routes)	43

"ESCORTING THE OSPREY; NEW AIRCRAFT--

SAME REQUIREMENT"

CHAPTER 1: FORWARD

In the year 2001, the United States Department of Defense Acquisition System will provide for the Initial Operational Capability of a revolutionary new weapon system, the MV-22 Osprey. This replacement for the USMC CH-46E and CH-53D helicopters will bring with it new range and speed capabilities. The increased range and speed of the MV-22 will cause interoperability problems, specifically with escort platforms and their tactics. The viability of present day tactics and future tactic's development are an important part in the determination of the Operational Effectiveness and Suitability of the MV-22. A desired result of any tactic is an increase in survivability. In today's transport helicopter tactics, the capability for survival is greatly increased by combat escort.

Representatives of The Marine Corps Deputy Chief of Staff for Aviation, in ANNEX F, the "Armed Escort" section of a draft of the *INITIAL DEPLOYMENT/EMPLOYMENT CONCEPT FOR THE MV-22 OSPREY DURING THE PERIOD 1995-2015* (7 April 1986), stated that:

"The primary escort aircraft for the MV-22 is the AV-8B close air support aircraft. ...To assist protection of the MV-22 assault force, the AH-1W will provide point defense from threatening fixed wing aircraft, conduct weapon systems along the route or around the LZ."¹

Colonel F. X. Chambers, the Acting Deputy Chief of Staff for RDQS, in his review of this document stated that **"The discussion of armed escort was not well focused...the study is best served by its omission."**²

The Joint Multi-Mission Vertical Lift Aircraft (JMVX) Operational Requirements Document (ORD) states that the V-22 "will encounter threats ranging from small arms and shoulder-fired surface-to-air missiles to anti-aircraft artillery, high performance fixed wing and rotary wing aircraft, lasers and integrated air defense systems."³ There is no mention in this current requirements document of a need for escort.

CHAPTER 2: PURPOSE

“The V-22 is not a combat aircraft, it is a transport aircraft.”⁴

“There is only one means in war: combat ... it is inherent in the very concept of war that everything that occurs must originally derive from combat.”⁵

Background

The first quote was made by the V-22 Assistant Program Manager for Test and Evaluation at a Test Plan Working Group in 1995. The second is from a better known military theorist. The dichotomy between these views is the essence of why analysis was completed. The purpose of this study was to advance, through research and original ideas, the discussion of employment of the V-22. There have been many debates centered on whether the V-22 should incorporate a gun. There have been few as to the necessity of escort for the V-22. This study demonstrates that a Self-Defensive capability is an absolute necessity due to the lack of a compatible escort at Initial Operational Capability (IOC). Additionally, V-22 program officers, reminiscent of "kind-hearted people who might ...think there was some ingenious way to disarm or defeat an enemy without too much bloodshed"⁶ need to be prevailed upon to change their attitude toward the employment of this aircraft. "War is such a business that mistakes which come from kindness are the very worst."⁷

New doctrinal concepts such as Operational Maneuver from the Sea (OMFTS) and control concepts such as Sea Dragon might require the independent lift of Marines and combat equipment up to 200 nautical miles (nm), at least 100 nm of which might be in a medium to high threat environment. While sustainability may be the "long pole in the tent" concerning these concepts overall, escort capability and its proportional influence on survivability of the V-22 is a major question to be addressed. V-22 Tactics, Techniques and Procedures (TTPs) need to be advanced along with these doctrinal advancements to deal with escort limitations and the threat

potential. Even without a trend away from linear tactics and toward "Single Battle" warfare, V-22 employment requires TTP advancements. This thesis will attempt to promote the type of thinking that will provide a baseline for TTP advancements necessary to support the Initial Operational Capabilities of the V-22 and aid further conceptual doctrinal advancements.

CHAPTER 3: THE ROLE OF ESCORT HELICOPTERS

"Historical examples clarify everything and also provide the best proof of empirical sciences. This is particularly true of the art of war."⁸

This Chapter details the history of escort of helicopters in an attempt to gain some insight into just how essential the protection of an escort is to transport helicopters. Lessons learned will be addressed in the conclusion section of this chapter and carried forward to the latter chapters.

US Army Escort Tactics/Utilization

The US Army began using helicopters in the Korean conflict in the 50's. Helicopter use in this conflict was primarily for casualty evacuation, search and rescue (SAR), observation and troop transport. Other than the use of personal firearms, to be discussed in the *Self Defense* section of Chapter 4, weapons were not used on board helicopters.⁹

The history of helicopter escort use by the US Army began in the Vietnam conflict. In 1962, the Utility Tactical Transport Helicopter Company (UTTHCO) came to Ton Son Nhut Vietnam with it's attached Twenty-fifth Transport Detachment and a directive to test the feasibility of armed helicopter escort for troop transport Piasecki CH-21 helicopters.¹⁰ The escort helicopters were UH-1A's and eventually UH-1B's. These helicopters were equipped with a 40 mm grenade launcher, a 7.62 mm machine gun, 2.75-inch rockets and M22 guided missiles.¹¹ Their first mission was flown in October and it soon became apparent that the use of escorts was an extremely effective method for suppressing enemy fire in the landing zones. UTTHCO initially used a ratio of three escorts per four transports with one observation aircraft. Additionally, T-28 "Trojans" were used for close air support. One aircraft would fly S-turns above and behind the formation and one would fly forward and below to try to suppress and draw enemy fire away from the helicopters.¹² There was a dramatic reduction in the number of helicopters hit by ground fire and in the number of total hits, although, the number of targets

presented to ground fire and the potential for receiving this fire increased.¹³

Helicopters later came to Vietnam as a part of Aviation Brigades in support of Army Divisions. Initially, "the tactical support section" of the Airmobile Company provided the "armed helicopter support for escort of the airmobile company."¹⁴ The aircraft to provide for this mission was again the UH-1B Huey, armed with four M60 machine guns and rocket launchers to escorting the H-21. With the arrival of the CH-47 Chinook, the Army envisioned a force of 47's escorted by Hueys. The speed and range differential between the Chinook and the Huey brought about a need for a change. The necessity for a "fast, well-armed helicopter to provide escort and fire support for the CH-47 Chinook" caused the initiation of a crash program that resulted in the development of the Huey Cobra.¹⁵ This came about due to the Chinook's speed and range capabilities and not necessarily from the need for more firepower.

The Army found that there were many benefits to the use of armed helicopters for support. Of particular benefit was their capability to operate "under low clouds, in weather that precluded the use of conventional strike aircraft" to escort airmobile operations.¹⁶ Additionally, Armed helicopters' "ability to respond immediately and accurately with their fire"¹⁷ was also a benefit over conventional strike aircraft. These two characteristics are what separate helicopters from fixed wing aircraft in the escort role. The added benefit of these capabilities has led to the Army's exclusive use of helicopters to escort helicopters.

A primary implication to be taken from the Army's use of escort helicopters is the necessity to provide some type of suppressive fires in the landing zone phase of operations. This suppression is required to have a point target accuracy that will not inadvertently endanger the helicopters with fratricide. The Army, in its search for decisions taken toward the escort of the CH-47 found that the UH-1 was incompatible due to a negative airspeed and maneuverability differential between the escort and transport aircraft. They also found that armed helicopters were preferable to fixed wing escort due to the capability of the helicopters to operate when low ceilings were present. The Army clearly realized that low speed maneuvering, higher speeds for

dashing ahead of the transports and a variety of weapons systems for firepower were the aspects necessary for escort of transport helicopters.

USMC Escort Tactics/Utilization

The USMC began operating helicopters in the Korean conflict. Armed helicopters were not used for escort as we know it today, although one tactic used by the Marines shows some promise for V-22 operations. The Marines used the H-19 for the evaluation of a new procedure called "hit an' git."¹⁸ This procedure involved ferrying a rocket launcher and its crew to a firing position, landing and firing a few rounds at an enemy position. They would then displace the still hot rocket launcher to a new position and fire again.¹⁹ The applicability of this procedure to V-22 tactics will be discussed in Chapter 6.

The first experience with helicopter escort in the Marine Corps was not notably different from the US Army's escort experience in Vietnam. HMM-362 initially deployed to Vietnam in 1962 with twenty-four UH-34Ds. Operations soon began to run into problems from vulnerability to ground fire. Procedures were established to have armed Vietnamese T-28's provide fire suppression in the landing zones.²⁰ HMM-163, on its rotation "in country", mounted M-60 machineguns and 7.62 mm miniguns on their H-34's to combat the small arms and anti-aircraft artillery (AAA) problem. In 1965, VMO-2 began escort operations at Chu Lai with UH-1E's with M-60 machine guns and 2.75 inch rockets.²¹ The AH-1 series aircraft was acquired for the same escort mission as the Army AH-1s. The Cobra's nose mounted gun turret gave "instantaneous fire suppression power: one ingredient vital to helicopter escort missions."²² In 1977, the USMC acquired the first AH-1T or TOW Cobra with the added capability of firing TOW or the Hellfire anti-armor missiles. For suppressive fires in the LZ, the aircraft could carry 750 rounds for its 20mm cannon turret, 76 2.75 inch folding fin aerial rockets (FFAR), four MK-81/82 bombs, two MK-5 bombs, four MK-76/106 bombs, two GPU-2/A 20mm gun pods, or sixteen 5 inch Zuni rockets. Special mission stores included M-118 smoke grenade dispenser,

ALE-39 chaff dispenser, SUU-44 flare dispenser, or two 100 gallon auxiliary fuel tanks. The aircraft was later qualified for the firing of AIM-9L Sidewinder air to air missiles, giving it the capability to provide transports with protection from aggressor aircraft.

In 1983, while conducting operations in Grenada, AH-1Ts of HMM-261 provided escort for the initial insertion of Marines into LZ "Buzzard." The fighting was light for this insert due to the efficient METT-T-SL²³ planning of HMM-261. This was fortunate for the Marines, because there was only a one to four ratio of escorts to transports (four Cobras escorting sixteen transports). The gunships were able to adequately suppress a 23 mm anti-aircraft gun positioned on a hill overlooking Pearls airfield, the MAU's objective for this initial insert. When the insert was complete, the Cobras were released to the control of the Eighty-Second Airborne. Two of the Cobras were providing support to Army units trying to break out of the Port Salinas area. One of the Cobras was downed by enemy fire and the other was shot down providing escort for a CH-46 that was attempting to rescue it's crew. This mission provides credence to an argument that transports should not be "dual-hatted" as escort aircraft.

The USMC has since progressed ahead of other services in developing helicopter tactics for assault support as well as tactics for evasive maneuvering against both helicopter and fixed wing threats. Present day USMC helicopter tactics are governed by the Assault Support Helicopter (ASH) manual series of publications. The ASH Manual describes, in detail, desired procedures for both fixed wing and armed helicopter escort.

Fixed wing escort tactics prescribed for USMC helicopters are categorized as attached, detached and preemptive sweep.²⁴ In the attached escort mode of operations, the fixed wing aircraft remains above the helicopters and the small arms or light AAA threat. This escort technique used for a low threat environment where an aggressor fixed wing threat is not present. The detached mode of escort is used for a high threat environment. Detached fixed wing escort is primarily for an air threat with an IR missile capability. A minimum response time of one minute is required always. The preemptive sweep uses fixed wing aircraft twenty to thirty nautical miles

ahead of the helicopter formation. These aircraft, with a radar capability provide threat detection and, if equipped with HARM, can provide for Suppression of Enemy Air Defense (SEAD).²⁵ When using fixed wing escort, LZ preparation is essential due to the lack of a point target suppression capability. The ASH manual prescribes the use of 20/25-mm guns and Fuel air explosives (FAE) in the LZ and 20/25-mm guns, napalm, rockets, FAE and VT-fused bombs on the LZ perimeter.²⁶ For either fixed wing or armed helicopter escort, the use of smoke to obscure the transports is a viable option.

USMC armed helicopter escort is divided into attached and detached escort as well. Attached, the most commonly used form of armed helicopter escort provides for responsive suppressive fires for any threat engagement. Special consideration needs to be given to the approach to landing zone phase of the flight. This stage of flight is when the helicopters are most vulnerable. For detached, armed helicopter escort, the escorts either clear a path along the escort route or rendezvous with the transports at predetermined points along the route. This shuttle procedure is desirable when the escort to transport ratio of two escorts per three transports cannot be achieved. The problem with this tactic is that the ground combat element's desire for rapid combat buildup in the LZ cannot be met. Additionally, the AH-1T's endurance does not support the shuttling of transports along the route by the escorts. This is one reason why past USMC helicopter transport missions have then been characterized by large flights of transports escorted by an inappropriate ratio of escorts.

Lessons learned from the USMC about escort are more capabilities based. The Marine Corps has adapted tactics to make up for a deficiency in assets for the escort role. As an example, the ASH manual states that the UH-1N, when used as an escort, requires the transport aircraft to fly at slower airspeeds to allow for escort maneuverability. Additionally, the manual states that, even the Cobra has no significant airspeed superiority as compared to the transports. The Cobra's deficiencies in airspeed are made up for by its capability to prepare the landing zone and provide suppressive fires through the use of its impressive and flexible weapon systems. The firepower and

zone preparation capabilities of the AH-1 are essential to the survival of the extremely vulnerable transports. If only fixed wing escort is available, the practice of LZ preparation is essential due to a inability to provide safe suppressive fires in the vicinity of the landing zone. The Marine Corps Aircraft Weapons and Tactics Squadron One (MAWTS-1) is tasked with writing the ASH manual along with members of specific type/model helicopter communities. The two-to-three ratio of escorts to transports prescribed by MAWTS- 1 can normally only be achieved with the use of some detached fixed wing assets. The pilots of the second Cobra downed in Grenada were making "dummy runs" on the anti-aircraft sites to draw fire away from a CH-46 that had a greater number of personnel aboard. This was a risk that is only feasible when the escort's are crewed by the minimum number of personnel with no passengers embarked.

USAF Escort Tactics/Utilization

The US Air Force's use of escort for helicopters began in Korea. In this conflict, escort was initially accomplished by F-80 Crusaders. These fixed wing escort aircraft were used to ward off North Koreans from downed fliers during search and rescue missions.²⁷ The primary escort for USAF SAR helicopters in Vietnam was the Douglas A-1 Sky raider (the Sandy). They escorted the HH-3 Jolly Green Giants and the HH-53 Super Jolly Green Giants on SAR missions.

The typical configuration was two transports and two escorts. The Sky raiders were effective due to airspeed differential and their heavy armament. During rescue missions, the "Sandys" would precede the SAR helicopter to the rescue site. One of the "Sandys" would fly "low and slow" attempting to draw enemy fire. Unfortunately, in many cases, the enemy would hold their fire, knowing that the A-1's were usually followed by the more lucrative target.²⁸

The MH-53J PAVELOW aircraft, which are flown by members of USAF Special Operations Command (AFSOC), are escorted by either the Sky raiders or proximity escorted by AC- 130H "Spectre" aircraft at the objective area. Conversations with their pilots indicate that

they are attempting to limit the use of the Sky raiders because their higher altitude tends to "give away" the position of the lower flying helicopters' position.²⁹ The Spectre is armed with a side firing 105 mm howitzer, a 40 mm cannon, and two 20mm Vulcan guns.³⁰ This is indicative of the USAFs understanding of the firepower necessary in the objective area. In some cases the MH-53Js have been escorted by MH-60K DAP (Direct Action Penetrator) aircraft of Task Force (TF)-160. This H-60 helicopter variant is armed with a forward firing suite that might consist of Hellfire or rockets attached to an external stores wing modification. These aircraft are additionally equipped with GE-CAL 50 mm machine guns for suppression. In Haiti, two of these helicopters provided shuttle escort for up to twelve MH-53J's³¹. As evidenced by the use of rockets, AFSOC has realized the necessity for escort aircraft to be capable of a great deal of firepower.

A lesson learned from the USAF's use of attached escort, in general, was that an attached escort, unless able to fly at the same altitudes and airspeed as the escorted aircraft, may cause more harm than good. Their use of shuttle helicopter escort in Haiti has shown the effectiveness of this procedure. Additionally, the use of rockets by their escort aircraft tends to provide a strong argument for this ancient but effective fire suppression tool.

The USAF, through the use of fixed wing escort, realized the enemy's capability to adapt to their tactics. The potential of the enemy to learn from our tactics brings the necessity to continuously re-certify and revise TTP's. This necessitates the flexibility in mission execution that is described in Chapters 5 and 6.

Foreign Service Escort Tactics/Utilization

The first foreign service use of helicopters to any great extent was the British in Malaya, as early as 1948, against Chinese Guerrillas. These helicopters, like the US helicopters used in Korea, were not armed and were primarily used for medevac and resupply. Beginning in 1954, the French, in the French-Algerian war, used helicopters for the above missions as well as in a

fire support role. Their armed helicopter experiences began with an automatic rifleman strapped to a litter external to an observation helicopter and progressed from there. The French tactics in this conflict eventually took on the appearance of the present day USMC helicopter escort procedures. The French Air Force would arm one in six helicopters and this helicopter would not carry troops. These armed aircraft would precede the transports to the zone, spraying the LZ with automatic weapons and rockets. The French were able to justify this technique by the fact that they had lost no helicopters to ground fire since the adopting it. The use of rockets by the French was also found to be a very well serving tactic. They eventually adopted seventy-two 37 mm rocket pods.³²

Another "foreign service" studied in this report was the Soviet Union, more specifically the Soviet Union's helicopter experience in Afghanistan. In Afghanistan, MI-8 "Hip" helicopters were used for troop, ammunition, and logistical transport. MI-24 "Hind" helicopters, "quick and accurate in fire power" were used to escort the MI-8's.³³ Soviet tactics for all heliborne operations changed radically over the period of the Afghan conflict. The proliferation of hand held surface to air missiles (SAMs) was greatly responsible for the changes in tactics. The use of hand held SAMs drove the Soviets to low level tactics and night missions using the Hind's optic systems³⁴ SAMs also drove the installation of IR countermeasures' systems on Soviet helicopters. The introduction of US made Stinger SAMs in 1986 all but curtailed the use of helicopter inserted patrols in Afghanistan.³⁵ The primary escort lesson learned from Soviet operations in Afghanistan is one of the helicopter's vulnerability to hand held SAMs. The tactics used to avoid exposure to these systems, specifically night and low level operations, were also adopted by US helicopters.

The British conducted helicopter escort operations in the Falklands War, using Gazelle helicopters to escort Sea Kings ashore. In one situation, two of the Gazelle gunships were shot down while escorting a logistics mission near the front lines³⁶. This was important in the fact that the gunships rather than the transports were shot down. This, along with the Cobra losses by the

USMC in Grenada would seem to add weight to the idea that you should not transport troops in aircraft being used for escort.

Conclusion

This study of past and present day escorts for transport helicopters has shown that there are a great deal of similarities between our services and foreign military services experiences. The conclusions that can be reached from this chapter revolve around speed, maneuverability, firepower and susceptibility.

Speed at least equal to the transports is essential to the escort's ability to fly attached escort. Additionally, the capability of an escort to precede the transports to a landing zone and react to threats requires the it to have a positive speed differential to the transports.

Maneuverability. For the escort to provide attached escort, it must have a low and high speed maneuvering capability at least equal to the transports. This is important for providing protection in all weather that the transports might experience. Additionally, to provide suppression of targets in an LZ, the escort aircraft must be capable of low speed maneuver required to suppress the target without endangering the transports in close proximity to it. The high inertia required by fixed wing aircraft for maneuver require them to fly higher than the transports in the attached role. This can have the disastrous effect of giving away the transport's position. Low speed maneuverability is also important due to reduced ceilings and visibility that the transport might encounter. If a fixed wing aircraft is the choice for escort, then it needs to be able to operate under overcast cloud layers or in extremely reduced visibility like helicopters.

Firepower. The history of escort has shown that the use of machine guns or cannons to suppress threats to the transports is simply not enough. Virtually every escort used in the past and at present can be armed with a variety of weapons. The one weapon system that seems to have been used the most frequently is rockets. This weapon system has proven itself to be an

invaluable asset, to the suppression of threats to the transports when they are the most vulnerable; in the landing phase of operations.

Susceptibility. The lesson learned by past operations here is that the escort, by the nature of its mission is going to place itself in a position to be more susceptible to the threat than the transports. In most of the conflicts studied, the escorts are traditionally the aircraft to be shot down. This has been necessary to the protection of the transports. In essence, to make the transports less susceptible, the escort makes itself more susceptible. In the past, examples of this have been both heroic and necessary. The point to be taken from this is that the transports should not be carrying passengers if tasked with the escort mission.

CHAPTER 4: DOES THE V-22 NEED AN ESCORT?

This Chapter will attempt, through a study of the V-22 and the threats to its operation, to determine whether an escort is necessary for combat operations of the V-22. It is important to state up front that, if the V-22 was to be employed today, many of the problems identified with the lack of an escort capability could be partially solved by night vision device (NVD) aided night operations. The use of night operations at IOC of the V-22 or later in its service life may not have the same effect. Night vision optics are being proliferated at least as much as other systems. They are being sold domestically through retail stores. With that said, the night does provide significant advantages to the V-22. This aircraft, with its capability for precise navigation through Global Positioning System (GPS), Light Weight Inertial Navigation System, Navigation Forward Looking Infra-red (Nav-FLIR), NVDs with Head-up Display (HUD) and it's integrated, state-of-the-art Cockpit Management System should "own the night." Doctrinal advancements such as Operational Maneuver From the Sea (OMFTS), though, will not allow for an operational pause to wait for it to get dark again. It is necessary then (given that night only averages twelve hours per day) that we, at a minimum, "Take out a lease on the day."

The Threat

The V-22 "will encounter threats ranging from small arms and shoulder-fired surface-to-air missiles to anti-aircraft artillery, high performance fixed wing and rotary wing aircraft, lasers and integrated air defense systems."³⁷

Future doctrinal concepts such as Operational Maneuver From the Sea (OMFTS) will require the V-22 to fly great distances, insert reconnaissance teams in possibly unknown threat environments, provide resupply of these reconnaissance teams, and provide assault transport to "project combat power through gaps, located or created, in the defense."³⁸ "These gaps may very well contain impediments...and the most effective route to the objective

may lead through a challenging coastal defense."³⁹ "Maneuver and fires must be"... swift and violent." ⁴⁰ The threat systems described in this section provide a great challenge to tacticians and planners in the future. The V-22 is an "Assault Support" aircraft and, as such, must be prepared for the inevitability of facing these systems.

Anti-aircraft artillery. The Secretary of Defense's Planning Guidance for 1997-2001 estimates that the number of air defense artillery (ADA) guns in China and North Korea will be twenty-four thousand to forty thousand. The extreme proliferation of this type of weapon system would seem to, by numbers alone, qualify it as one of the biggest threats to the V-22.

Shoulder Fired IR Surface-to-Air Missiles. In Vietnam, the survivability of helicopters was initially questionable. Tactics were quickly adapted to the situation. Given only an enemy small arm's anti-air capability, helicopters were flown at high altitudes above the threat. The proliferation of hand-held, heat seeking surface to air missile systems later in the conflict caused mission planners to adopt low level tactics to reduce exposure time and decrease susceptibility to the SAM threat. The Soviets in Afghanistan were given the same lesson with almost the same learning curve. The best way to defeat these systems is through avoidance. The intelligence support required to locate all hand held missiles is an impossible task. The capability to locate all within a limited geographic area is a possibility. A secondary method would be to decrease exposure time to limit the capability for a firing solution or "lock on." Tertiary to these procedures would be the use of countermeasures' systems. In Operation Desert Storm, low-level and aided night operational tactics were used to avoid the threat due to a lack of intelligence with regard to the location of these hand held missile systems.

High Performance Aircraft, US and European as well as Former Soviet high performance aircraft are widely proliferated along with air to air missiles. The Russian MIG-21 has been aggressively sold along with "state of the art" avionics and missile systems.⁴¹

Integrated Air Defense Systems. The threat of an enemy integrated air defense systems (IADS) will depend, in a large part, on what stage of the conflict that flight operations are being

conducted. In the MLR COEA, mission effectiveness of the V-22 was analyzed during several stages of both hypothetical Major Regional Conflicts (MRC) and in a Lesser Regional Conflict (LRC). In the MRCs, the threat IADS medium and high altitude anti-air capabilities had been significantly reduced before the first use of assault waves of V-22s and CH-53Es. Additionally, friendly aircraft had gained and maintained air superiority. The threat systems facing the V-22 in this "year 2005" South West Asia (SWA) MRC COEA scenario consisted of 7.62mm assault rifles, Armored Personnel Carriers (APCs) with 7.62mm anti-air machine guns (AAMG), LZ.7mm Medium AAMGs, 14.5mm Heavy AAMGs, SA- 14 equivalent Infra-red (IR) seeking shoulder fired missiles, and 35mm GDF-005 Medium anti-aircraft guns with Skyguard fire control radars.⁴² This threat seems to be representative of a medium to high threat anti-air environment.

Anti-Helicopter Mines. A relatively new threat to rotary winged aircraft is the anti-helicopter mine that may be effectively used to defend against ship to shore helicopter assault in the littorals.⁴³

Coastal Defense Artillery. The former Soviet Union's export of coastal defense artillery systems, some of which are radar guided and up to 123 mm, provide a significant threat to aircraft operating up to 200 knots.⁴⁴

Additional Low Level Threats. Logging cables, wires and towers are a sometimes unintentional threat to low flying helicopters. These hazards will especially be a threat to the V-22 in the low level environment due to increased airspeeds. The lack of adequate mapping of littoral areas, specifically the 1:50,000 variety necessary for low level route planning, makes this a serious problem.⁴⁵ Additionally, at least fifty percent of the US Embassies in the littorals are over two hundred nautical miles in-land. A non-combatant evacuation operation (NEO) type operation might require just this type of over-land flight operations.

Speed and Survivability

The survivability or, more specifically, the susceptibility of an aircraft to the systems described in the previous section is directly related to speed. Most weapons threatening the V-22 will require a line of sight for effectiveness. An increased speed reduces the aircraft's exposure time to ground launched anti-air weapons. A survivability study comparing the V-22 to several helicopters was conducted by NAWC AD China Lake in 1991.⁴⁶ The results of this study were further validated by Operational Testing conducted by the V-22 Multiservice Operational Test Team in 1994.⁴⁷ An important question that remains to be answered deals with preferred operational altitudes and airspeeds. The closer to the ground that an aircraft is flown, the slower it must be flown for both obstacle avoidance and accuracy in navigation. Is the V-22 more survivable at lower altitudes and slower airspeeds or at higher altitudes and higher airspeeds? The study conducted by China Lake found, through modeling and simulation (M&S), that exposure time and therefore susceptibility to threat systems was less when flying at 250kts and 300ft AGL than when flying at 50ft AGL with only 120kts of airspeed. This determination was based upon a laboratory computer model.⁴⁸ Operational test data provided in the following section seems to validate these figures. Another study in 1992 was conducted as a portion of a larger DC/S Aviation commissioned Marine Aviation Combat Element (MACE) 2010 study. This study titled *Susceptibility Reduction Through Terrain Masking and Airspeed*,⁴⁹ was performed to determine if susceptibility would be lessened substantially by the capability of VTOL aircraft to fly at extremely low altitudes. The study used computer modeling with DMA terrain models to attempt to determine what susceptibility reduction might be gained through certain combinations of terrain masking and airspeed. This study compared line of sight information for aircraft flying at altitudes from 25 to 150 feet and airspeeds between 120 and 250 knots. The results of this study suggested that flight at 50 feet AGL maintained over undulating to rolling terrain reduced the threat weapon coverage by a medium range missile system, a shoulder-fired IR guided missile system, and a mobile missile/gun system by 50 to 70 percent.

The study also found that, due to decreased exposure time by flying at higher airspeeds enabled by higher altitudes, the susceptibility was the same as the lower altitude and lower airspeed. The report recommends that advanced avionics be used to allow the VTOL aircraft to fly at these lower altitudes.⁵⁰ There is a problem with this recommendation. If the aircraft has the same susceptibility flying at 25 feet and 120 knots that it does when it flies at 250 knots at 150 feet, then it might as well fly higher and faster. The higher airspeed provides greater effectiveness through decreased time to complete the mission. The higher altitude provides for less wear and tear on components, and less fatigue on both crew and passengers. Additionally, the model used for this study did not model vegetation which might have the effect of making the higher altitudes even more survivable. The following discussion of the overall susceptibility of the V-22 provides some further argument for this.

Susceptibility. The V-22's range provides flexibility to the mission planner for routing. The ability to completely avoid a threat by horizontal or vertical circumnavigation provides for a reduction in susceptibility. To acquire these increased ranges, the V-22 must fly at higher, more efficient airspeeds, making higher altitude flight than helicopters necessary. The flexibility of speed and range also reduces susceptibility by preventing the threat from reacting and massing forces over the extended area that the V-22 can cover.

The susceptibility of the V-22 was assessed by Operational test personnel in 1994 who observed its performance as compared to other helicopters during some mission type scenarios.⁵¹ The Table 4-1 details the aircraft and the altitudes and airspeeds that were flown during this assessment. The LOW altitudes and airspeeds in the chart for the V-22 were taken from the China Lake survivability study mentioned previously.⁵² The HIGH altitudes and airspeeds were flown by operational test pilots. Two FMF Low Altitude Air Defense (LAAD) Teams were placed in separate areas along the route to assess exposure time of each aircraft at various altitudes and airspeeds. Exposure times based on aural and visual cueing and Infrared (IR) Surface to Air Missile (SAM) tracking were used to assess susceptibility.

Table 4-1. Susceptibility Altitudes and Airspeeds⁵³

Aircraft	HIGH		LOW	
	Altitude	Airspeed	Altitude	Airspeed
SH-60F	300	150	75	130
CH-46	300	145	75	110
CH-53D	300	130	100	120
V-22	300	275	150	200

Table 4-2 contains a comparison of the tracking times between aircraft flown at their HIGH altitudes and airspeeds. While the sample size for each aircraft is small, Table 4-2 shows that the V-22 possesses a potentially significant advantage in reduced exposure time.

Table 4-2. Aircraft Tracking Times in the HIGH Scenarios⁵⁴

Aircraft	Tracking Times (In Seconds)		
	Aural	Visual	Lock-on
SH-60F	103.0	37.3	22.3
CH-46	147.3	56.7	40.0
CH-53D	130.3	68.7	41.3
V-22	45.0	20.5	15.0

The HIGH and LOW scenarios were compared to determine if any value is gained in trading a higher airspeed for a lower altitude. Table 4-3 shows the results of this comparison.

Table 4-3. HIGH and LOW Scenario Comparison.⁵⁵

Aircraft	Tracking Times (In Seconds)					
	Aural		Visual		Lock-on	
	HIGH	LOW	HIGH	LOW	HIGH	LOW
SH-60F	103.0	125.4	37.3	35.3	22.3	6.3
CH-46	146.3	146.7	56.7	33.0	40.0	13.3
CH-53D	130.3	78.3	68.7	21.5	41.3	12.0
V-22	45.0		20.5		15.0	

Detection of the V-22 by aural and visual cues, and exposure time near the LAAD teams was significantly reduced when operating in the fixed wing mode. Visual and aural cues were similar to the CH-53E when the V-22 was in the conversion mode.

From Table 4-3, the aural comparison between the HIGH and LOW scenarios is inconclusive. However, visual and lock-on tracking times for the helicopters in the study

decrease dramatically with a lower airspeed at a lower altitude. The V-22, which was only flown at the HIGH altitude of 300 feet showed exposure times approximately equal to the helicopters flown at extremely low altitudes. These figures seemed to be in-line with the results of the China Lake modeling and simulation.

Typically, the landing phase is the most vulnerable due to slow airspeed and high predictability. The use of suppressive fire is the primary method of reducing susceptibility during this terminal phase. The V-22 demonstrates a significant acceleration advantage over other aircraft. This advantage could be used to more rapidly egress from a hot LZ. The V-22 also demonstrates good maneuver capability. Even at high gross weights, the V-22, based on design predictions, will have approximately 3 g available in airplane mode and 1.5 g in helicopter mode. These figures were validated by a multi-axis maneuver simulation. The simulation demonstrated that the V-22 could perform a wide variety of high and low altitude combat maneuvers incorporating both helicopter and fixed wing tactics.⁵⁶

The size of the V-22 negatively affects its susceptibility. In comparison to the CH-46, certain aspects of the V-22 make it a larger target and therefore more susceptible due to visual detection, radar cross section and IR reflectance area from the beam and planform aspects.⁵⁷ The V-22's IR signature and its effect on the susceptibility to heat seeking missile systems is an unknown as well as the effectiveness of countermeasures systems to be installed on the aircraft at IOC. The V-22 does emit a significant exhaust plume based upon IR imagery from OT-IIB testing. The susceptibility to small, IR guided missiles is a real concern.⁵⁸

Vulnerability. The vulnerability of the V-22 has been greatly reduced by system design features. System design vulnerability reduction features of the V-22 include: component redundancy, component location, passive damage suppression, active damage suppression, component shielding, and component elimination.

Battle damage tolerance is built-in to the aircraft by means of the composite construction and redundant and separated flight controls, electrical, and hydraulic systems. This is augmented

by transmissions capable of running for extended periods following loss of primary lubricating oil, and by the capability to operate the aircraft with only one engine. The V-22's flight control critical subsystems and primary load carrying members of the aircraft structure have the potential, (through the most recent Live Fire Data) to continue to function after sustaining damage from 12.7 mm and 14.5 mm threats.⁵⁹ Other vulnerability reduction and crash worthy features include self sealing fuel tanks with nitrogen gas inerting, an anti-plowing nose structure, energy-absorbing landing gear and seats, and crash worthy cargo restraints. The basic design of the airframe contributes to crash survival with the high mass components, mounted at the wing tips, designed to break away on impact. Chemical, biological and radiological (CBR) protection includes cockpit and cabin over pressurization, a contaminant filtration system, and airframe materials selected to facilitate effective decontamination. The aircraft will be compatible with aircrew personal CBR protective equipment.

An integrated defensive electronic countermeasures (DECM) suite including a radar warning receiver (APR-39A (V) 2), a missile warning set (AAR-47), a laser detection system (AVR-2A) and a countermeasures dispensing system (CMDS) (ALE- 47) is planned for the V-22. This DECM suite should provide for self protection of the V-22 but there are some inherent problems. The AAR-47 missile warning set has a hardware link to the CMDS, but there is no capability for a crewmember, in the rear of the aircraft to manually dispense chaff or flares. Additionally, the V-22 will only have the capability for carrying 60 expendables, the standard number that USMC helicopters carry today. With the extended range of the V-22, this number may be insufficient.⁶⁰

Self Defense

"Besides the perceived need for helicopters to attack specific ground targets, the arming of helicopters in general fulfilled also a deep-seated psychological need: soldiers are more confident and will go forward to meet the enemy if they can pull a trigger. Similarly, the crew of a helicopter is less likely to hold back if it can fire on the enemy. Furthermore, ground troops will not fire so resolutely at a helicopter that is spewing lead at them."⁶¹

This quote from a Soviet General provides a good argument for a robust self defense capability from a psychological and survivability aspect. There are some counter-arguments to be heard in this regard. Although the Navy is not necessarily thought of as an innovator for helicopter tactics, Naval helicopters were the first helicopters to fire weapons in combat. This unofficial "first usage" occurred in Korea, in 1951. Initially, the North Koreans hid behind trees or got down in the underbrush when helicopters passed. That was until Lieutenant J.G. John W. Thornton and his crewman Petty Officer Whitaker began "firing .45-caliber pistols and carbine rifles at" and dropping hand grenades on North Korean troops from their HOS3- 1 "gunship." Their mission was SAR and "mine and artillery spotting" but they tended toward offensive operations if conditions tended themselves toward it.⁶²

Once the North Koreans realized that the helicopter was a potential threat, they began firing on them with small arms. There were other reported cases of Navy HOS3-1's being aggressed by North Korean MIG-15 jets ⁶³, though probably not for the same reason. The JMVX-ORD requires a "mission configurable, selectable rate of fire (air-to-ground and air-to-air) weapon system compatible with night vision devices."⁶⁴ Additionally, the ORD states that a shortcoming of the existing medium lift helicopter system was "inadequate self-protection."⁶⁵ Here the necessity for a self defense capability seems to be well understood, but, according to information from the V-22 Critical Design Review of 13-15 December 1994, the current design calls for weapon "space, weight, power and structural provisions only."⁶⁶ The V-22 requires the capability to provide self protection should an escort with an immediate response and point target suppression capability be unavailable.

Conclusion

At first glance, the V-22s survivability enhancements would seem to dilute the argument for an escort requirement. The V-22s limited expendables, limited or not installed self-defensive weapon capabilities, increased size, radar signature, and unknown IR signature when viewed in

conjunction with the proliferation of threat weapon systems raises the discussion level. The V-22 will face a threat that is ever increasing in lethality and in resistance to countermeasures' systems. There is a very noticeable disconnect between the V-22 acquisition personnel and Headquarters USMC about the employment of this aircraft. To produce an aircraft with the capabilities of the V-22 and assume that it will be employed as a C-130 is irrational. The only conclusion that can be reached by this Chapter is that the V-22 will require a very robust self defense capability as well as, at a minimum, proximity escort in route and attached escort from the initial point to the landing zone, in the landing zone environment and upon egress from the zone.

CHAPTER 5: ESCORT OPTIONS

"Only a helicopter can match the speed, range, manoeuvrability and firepower of another helicopter"⁶⁷

Chapter 3 attempted to determine historical basis for the requirement of escort for transport helicopters. Chapter 4 attempted to determine what capabilities inherent in the V-22 might negate the requirement for escort. This Chapter will attempt to determine what escort option or options might be best suited for protection of the V-22.

What is a compatible escort?

In Vietnam, the Army changed their plans from having a fleet of CH-47's protected by armed Hueys to the acquisition of the AH-64. Although the Hueys were adequately armed for the threat, they did not possess the range and speed of the 47's. What characteristics make an escort compatible with the V-22?

A compatible escort for the V-22 should have the firepower and point target capability to avoid fratricide in the escort role and still have speed and range at least comparable to the V-22. It should be able to aggress "threats ranging from small arms and shoulder-fired surface-to-air missiles to anti-aircraft artillery, high performance fixed wing and rotary wing aircraft."⁶⁸ The escort should have a speed capability to enable it to dash ahead of the V-22 in order to provide reconnaissance of and prepare an LZ. The dash speed is also important to the escort for diverting for suppression missions and then returning to the flight of V-22s. Additionally, the escort should have the range capability to accompany the V-22 in the accomplishment of a Joint Requirements Oversight Council (JROC) validated 200 nm land assault mission.⁶⁹

The use of dedicated, attached fixed wing aircraft shows some possibilities. The limitations associated with this option are limitations in the endurance, low speed maneuvering and point target suppression capabilities of both the AV-8B Harrier and the F/A- 18C/D Hornet.

The highest cruise airspeed for the V-22 is approximately 255 knots. This airspeed is incompatible with efficient maneuvering speeds for both USMC fixed wing attack aircraft. This aircraft, in an attached escort role would have to fly a racetrack, cloverleaf or other escort pattern around the V-22's in able to maintain their maneuver capabilities. These capabilities would be necessary due to the threat of aggressor fixed wing aircraft or helicopters. This use of these escort patterns would not be entirely debilitating to the support of the V-22. Transport helicopters, in the landing zone operations phase, are often supported by escort helicopters in just this fashion.

Both the AV-8B and the F/A-18 can provide adequate protection, either in the proximity or preemptive sweep roles. The firepower of these aircraft is sufficient for LZ preparation, or protection from aggressor fixed wing or helicopters. For other enroute threats, their response time and the large CEP (Circular Error Probability) of their weapons limits their capability to suppress threats until the V-22s have effected their "scatter plan." Additionally, because of the longer range of the V-22, there might be a requirement for more fixed wing assets for escort of the V-22 on any given mission. The limitations discussed earlier about adverse weather still apply. The same capabilities and limitations that are seen in fixed wing escort of helicopters should be witnessed in fixed wing escort of the V-22. The detached fixed wing escort should never be more than seven nautical miles away for a one minute response time. The same TTPs applied in the ASH manual to helicopters with fixed wing escort can be applied to fixed wing escort of the V-22. Detached fixed wing escort will solve a portion of the V-22 escort dilemma, but not the entire problem.

The only type of aircraft to have compatible range, speed and the low speed maneuverability necessary to provide for a close proximity target suppression capability and thus attached escort would be a heavily armed tilt-rotor, as addressed by the VMAO program.

What about the VMAO?

This escort aircraft, with tilt-rotor capabilities, reduced profile and increased firepower is the obvious choice for escort of the V-22. The VMAO program was initiated to meet these requirements along with observation requirements previously met by the OV-10 and utility aircraft capabilities of the UH-1N. In the 1996 Program Objective Memorandum (POM), a decision was made to defer the VMAO aircraft until the year 2020. This was due to fiscal constraints created by the acquisition of the MV-22, F/A18E/F and other, "higher priority programs."⁷⁰ As such, the VMAO is not a realistic option for escort of the V-22.

Will the Four Bladed AH-1W (4BW) be compatible with V-22 Operations?

Early in 1995, USMC Systems Command Analysis Division was commissioned by Aviation Plans and Weapons. HQMC to perform a quick look analysis to assess if an AH-1W improvement plan incorporating a new four bladed rotor system (4BW) would provide an increase in survivability of the V-22 and increase battlefield effectiveness in the MLR COEA South-East and South-West Asia Scenarios. In this study, the 4BW's were not flying attached escort for the V-22. They were providing for threat suppression along the intended route of flight. The results of this study are adequate to provide implications toward the 4BW's increased contribution to the assault support transport mission only if supporting in this fashion. The 4BW is forecast to have a range of 302 nm at Sea Level and 103 degrees Fahrenheit⁷¹ with no fuel reserves and only around 260 nm range with twenty minutes reserve.⁷² This would give the 4BW a mission radius of 130 nm at best, without taking into account any loiter time enroute or at the LZ. The 4BW will not have an in-flight refueling capability. These figures were computed without the additional 2001bs of weight added by an additional wing station on each side of the

aircraft. The additional wing stations were considered for the suppressive capabilities in the study but not for the ranges and airspeeds in the chart. A comparison of forecast 4BW capabilities compared to the V-22 performance requirements and capabilities is provided in Table 5-1.

Table 5-1: V-22, AH-1/ 4BW Comparison⁷³

	V-22 Rqmt.	V-22 Capability	AH-1W	4BW
Vel. Best Range	n/a	207 kts	120 kts	126 kts
Vel. Max (MGW)	n/a	262 kts	140 kts	149 kts
Mission Radius	400 nm	262 nm ⁷⁴	123 nm	151 nm
Vel. Max . End.	n/a	225 kts	74 kts	75 kts

This chart clearly shows the incompatibility of the 4BW in the escort role with regard to range and speed. The capability of the 4BW to escort the V-22 in its JMVX ORD required, JROC validated "Land Assault Trooplift" mission would appear to be limited. To enable the threat suppression advanced by the 4BW study along a 200 nm route of flight would require a large number of 4BW's as well as the use of Forward Arming and Refueling Points (FARPs). Another mission requirement detailed in the JMVX ORD is an "Amphibious Raid." In this mission scenario the same mission range requirements exist. Additionally, in this scenario the V-22 must loiter at the LZ for up to thirty minutes. A raid scenario such as this would make the use of FARPs by the escort even more difficult. The thirty minute loiter time would cause additional 4BW's to be required for the escort role, possibly relieving one another in mid-mission.

The question then arises about the capability of the 4BW to escort the V-22 on missions with a shorter radius. The V-22 in the "Amphibious Troop Lift" requirement must take off from ship, and, after a loiter of 40 minutes, proceed 50 nm to an LZ, return and repeat the mission without the loiter.⁷⁵ The 4BW would be capable of escort in this mission scenario, but only from the initial point to the LZ. This is the portion of the flight that might be flown by the V-22 in the

helicopter mode. For the rest of the flight it is more likely that the aircraft will be flying at the higher airspeeds associated with the airplane mode.⁷⁶ There are many reasons for this, not the least of which is the increased efficiency of higher airspeeds. The question that was raised in Chapter 4 regarding the most survivable altitude surfaces again here. The question was "Is the V-22 more survivable at lower altitudes and slower airspeeds or at higher altitudes and higher airspeeds?" A combination of studies and actual operational testing inferred that flight at 300 ft at 230 kts was as survivable as flight at 50 ft and 120 kts or less. The question now is, what happens if an escort is added to the lower altitudes and airspeeds? In this flight profile, attached escort by the 4BW would be possible, but would it be more survivable? It would require the transports to cut their airspeed in half which might also hinder their ability to evade a threat. Additionally, the V-22, when flying in the airplane mode has the aural signature of a turbo-prop aircraft, significantly reducing its chance of detection. When operating in the helicopter mode it has a much greater aural signature. This combined with the aural signature of the Cobra, albeit reduced in the 4 bladed design, might cause more susceptibility and lower survivability than unescorted at higher altitudes and airspeeds. Also there is a matter of trade-off again. The trade is between the greater efficiency at 230 kts and an undetermined increase of survivability with attached escort at lower altitude. With the above argument accepted, the utility of the 4BW as an attached escort for the V-22 is limited. The answer to the question of compatibility of the 4BW is that the 4BW is possibly compatible with the V-22 from IP to LZ, but it is, in no sense of the word, the "desired" escort for the V-22.

Why can't there be a Compatible Escort V-22 IOC?

The Acquisition System today requires anywhere from eight to ten years to develop and produce a new weapon system. An off the shelf item or modification of an existing system takes less time, but there is nothing being produced today that can escort the V-22 over its entire range of performance. The only way that there could be a compatible escort at or near IOC would be to

procure a heavily armed version of the V-22.

The AV-22?

Only a tilt-rotor can match the speed, range, maneuverability and firepower of another tilt-rotor. The 4BW will be capable of providing escort for the V-22 from IP to LZ in certain missions but not in all missions. Weight, space and power are being allotted for a turreted GE-50 caliber machine gun on the V-22. In cases where attached helicopter escort is not available or feasible, a 50 caliber machine gun will not provide adequate suppression. A possible solution comes through the use of rockets. Historical information has shown that rockets have been the weapon of choice for threat suppression in and around the LZ. This has been due as much to their simplicity and ease of use as to their suppressive capability. In essence, with rockets you get "more bang for the buck." An important consideration in the arming of transports comes from lessons learned in past operations. The transports assigned to the escort role should have the capability to carry an increased number of expendables. The escort, by the nature of its mission is going to place itself in a position to be more susceptible to the threat than the transports.

Conclusion

The only aircraft that can adequately provide attached escort protection to the V-22 is another tilt-rotor. The limitations of range and speed of the 4BW would only allow for it to only provide adequate protection from the IP to the LZ, and then only in those cases where the V-22 is not used to its optimum capabilities. Current USMC fixed wing aircraft are capable of detached and preemptive sweep escort of the V-22. Limitations of fixed wing escort due to weather and response time are important considerations. The V-22 should be better armed, possibly with rockets, and in some cases be used for escort. When it is used to escort other aircraft, it should operate purely in that role without passengers embarked.

CHAPTER 6: NEW TACTICAL EMPLOYMENT

The previous Chapters have determined that there is a necessity for escort of the V-22. Additionally, it has been determined that there is little chance of having a compatible escort at IOC. Given these assertions, this Chapter will attempt to propose some tactics that might limit the effect of not having a compatible escort.

Aren't sections better anyway?

The Medium Lift Helicopter community has grown accustomed to large flocks of helicopters being escorted by a few attack aircraft, normally two escorts at the front and two at the rear. This has been done in the past out of necessity. The "extremely lacking" capabilities of the CH-46 compounded with a shortage of escorts drove the Fleet to operations such as this. With the lack of a compatible escort, the Fleet may be driven to something of it's benefit this time. With the lack of a compatible escort, the best option for escort of the V-22 on the enroute phase of flight in the airplane mode is detached fixed wing escort. The most flexible and survivable formation is the section. The ability to maneuver with speed is very important. The maneuverability of a section is the only feasible formation for execution of a scatter plan or any other formation maneuvering in the fixed wing mode of flight. The basic concept to be explored involves sections of aircraft traveling separate routes to an IP. With precise navigation and timing capabilities inherent in the V-22s CMS, the sections rendezvous with other sections at the IP and continue inbound to the LZ with the appropriate speed of combat power build-up requested by the ground commander. This idea should be kept in mind when reading the following sections on high and low altitude tactics.

High and Low Altitude Tactics

In 1993, while contributing to the Center for Naval Analysis, Marine Corps Medium Lift Requirement, Cost and Operational Effectiveness Analysis, the V-22 representative was asked to provide tactical expertise concerning preferred altitudes and airspeeds for V-22 missions. For the South East Asia Scenario, the battlefield shaping process had rendered the North Korean TAD system ineffective above 18,500 feet AGL. He stated that the V-22 would fly the missions at 20,000 feet, thus avoiding all anti-air threat. This recommendation was not accepted due to the desire to maintain a level playing field for the helicopter "competitors." Nonetheless, the V-22 provides a unique advantage in the exploitation of gaps, both horizontally and vertically. The lack of a compatible helicopter escort for the V-22 is a secondary reason for the exploration of these tactics.

The following sections in this thesis will attempt to develop high and low altitude tactics for employment of the V-22. Specific missions might require the V-22 to operate in any combination of these profiles dependent upon threat, terrain, weather or other mission variables. For the purpose of this discussion, high altitude tactics will be considered as those that allow the aircraft to operate above the envelope of enemy low and some middle level surface to air systems. Low altitude tactics will be those which are the most dependent upon terrain masking for threat envelope avoidance. These tactics, due to the added hazard of terrain impact, might involve slower airspeeds in the helicopter mode of flight at times. The use of high altitude tactics requires the development of high altitude penetration tactics. The use of sections by separate routes drives development of both convergent and divergent tactics for rendezvous or breaking up sections.

The following sections provide other tactical proposals to limit the necessity for escort. They should be viewed with an open mind as they are intended to generate discussion rather than future V-22 tactics. These tactics, as a proposed way of dealing with the V-22 escort problem, are only one of the many possible ways to "skin" this cat.

High Altitude Tactics. In recent USMC assault support helicopter tactic s development, the battlespace has been viewed as linear, with lower altitudes always being preferred for threat exposure avoidance. For OAS and AAW missions, it has been thought of three dimensionally. The V-22 gives the Assault Support Transport mission the capability to operate in three dimensions. Traditionally, lower altitudes have been viewed as more survivable for assault transport due to terrain masking, The V-22's capability to fly effectively and efficiently at altitudes up to 20,000 ft MSL allows for some exploitation.

During Operational Test OT-IIB, NAVAIR provided data estimating the cruise ceiling (300 ft/mm climb capability) for the MV-22. This data predicted a cruise ceiling of 14,500 ft at a gross weight of 60,500 lbs. The cruise ceiling increases in a near-linear fashion to 25,000 ft at a gross weight of approximately 37,500 lbs.⁷⁷ The approximate mission take-off gross weight for the MV-22 with 24 combat loaded Marines is 49,583lbs.⁷⁸ Given this value, the cruise ceiling would be approximately 19,500ft. The cruise ceiling would increase approximately 10,000ft for each 23001bs of fuel burned.

As described in the "threat" chapter of this thesis, the initial altitudes flown in Vietnam were above the AAA threat effective altitudes. Helicopter pilots would practice spiral approach tactics to minimize exposure time. These approaches, exhibiting extremely high rates of descent, would attempt to allow contact with only threat systems in the immediate vicinity of the landing zone. As the war progressed, the availability of heat seekers drove the development of low altitude tactics. These tactics were initially the only option for reducing exposure to these threat systems. Recent developments in the use of surface to air countermeasures' systems have added to survival capabilities in the low to middle altitude environments.

Through the battlefield shaping process in the Gulf War, the Iraqi IAD system was reduced enough to allow for fixed wing aircraft operations at high altitudes over the Kuwait theater of operations (KTO). The shaping process was not extensive enough to allow for a helicopter insert which was aborted because of a low altitude anti-air threat on the eastern

portion of the battlespace. With the increased altitude capabilities (more specifically, the capability to fly at high airspeeds, for greater distances at higher altitudes) assault support transport tactics can now come full circle. The capability to fly above maximum effective altitudes of many threat systems gives the V-22 the flexibility to completely avoid the threat during a large portion of flight enroute to the objective area. This flight profile would be especially alluring when developing the flight tactics for doctrinal concepts such as Operational Maneuver from the Sea (OMFTS). In some renditions of OMFTS, the V-22 would be required to fly up to 200 nautical miles, 100 of which might be over hostile territory. The use of a terrain flight profile for the overland portion of flight would be extremely fatiguing to both crew and embarked Marines. Low level flight also subjects the aircraft to numerous impact hazards identified in Chapter 4. Chapter 4 also identified that the lack of adequate mapping of littoral areas, specifically the 1:50,000 variety necessary for low level route planning, makes strike hazards a serious problem. Additionally, as stated earlier, at least fifty percent of the US Embassies in the littorals are over two hundred nautical miles in-land.⁷⁹

A major detractor to high altitude tactics comes about through the inability of the V-22, in its present proposed configuration, to provide oxygen generation for more than four crewmembers. The ORD calls for the capability for on board oxygen for four crewmembers and three passengers.⁸⁰ This problem could be solved by portable oxygen systems for embarked Marines. High altitude operations were considered early in the V-22 program for self-deployment with passengers but later disregarded due to human factors problems centering around oxygen and passengers. This was a valid problem given the flight time required for self-deployment ranges. Little discussion was perceived, probably because the on-board oxygen capabilities to support four crewmembers and twenty-four passengers for these long self-deployment times was not easily achievable then.

Today, oxygen systems have advanced to the point where portable systems operating off liquid oxygen are efficient, light-weight and affordable. A light weight canister is available that

will support one Marine for up to six hours. This is not long enough for the self deployment mission but it is certainly enough for a three hundred mile OMFTS mission. If the maximum effective altitude of anti-air systems has been reduced to allow for un-aggressed flight operations in the 15,000 to 20,000 ft area, then this should be exploited. The penetration point for the V-22 can now be a point at 15,000 ft above the LZ. In essence, helicopter tactics are rotated ninety degrees. The area where the V-22 might be aggressed becomes a small area from surface to 15,000 feet. It might be possible to mold this area, through Intelligence Preparation of The Battlespace (IPB), reconnaissance and shaping, into a "penetration zone" for V-22 penetration. The escort requirement, in this case, would be reduced to preemptive sweep and detached fixed wing assets on the enroute portion of the flight.

Proposed Procedure. The procedure described will be for an OMFTS scenario. The use of this long range mission, by the tenants of OMFTS, would be to strike at an enemy critical vulnerability. The general mission to be described is a troop lift of a company of Marines to a landing zone. The landing zone is 100 nautical miles inland. The point of departure is an LHD 100 nautical miles from the beach. Assets involved are a Carrier Battle Group (CVBG) and an Amphibious Ready Group (ARG).

Intelligence Preparation of the Battlespace - The selection of the landing zone as well as the "penetration zone" for the penetration of the V-22 would be heavily dependent on the use of IPB. TAMPS or other computer based mission planning could be used to determine line of sight capabilities for known threat anti-air systems. Intelligence computer capabilities could be used to determine areas of "no-go" trafficability for threat armored or artillery systems. A large area composed of this type of terrain would be ideal for the base of this "penetration zone." The greatest threat to the flight of V-22s, Air Defense Artillery (ADA) and hand-held SAMs, could be limited in this fashion. Additionally, the enemy's response to the insert could be predicted and countered through the identification of his approach corridors.

Reconnaissance Requirements - After an adequate IPB has been conducted to determine

several possible penetration zones, reconnaissance assets would be used to select the best areas and reduce risk. Identification of "no-go" terrain and line of sight predictions from the IPB process would limit exposure to ADA and SAMs, but some reconnaissance is necessary to determine threat small arm's disposition in the potential zones. The use of personnel sensors (Scamp assets), satellite imagery, RPVs, and possibly reconnaissance personnel inserted for the performance of "infestation missions" should be able to provide an accurate picture of the base of the zone. A major benefit of high altitude tactics is the reduced area reconnaissance and preparation requirement. Rather than the need to reconnoiter an entire route of flight, (a nearly impossible task for this OMFTS mission) there is only the necessity for reconnaissance of the threat capabilities in the zone.

Upon selection of the appropriate zone, the continued use of Electronic Warfare (EW) assets is important to the high altitude survival of the V-22. It is important to realize that, what was considered to be a safe altitude for high performance jets may not be as safe for the V-22. The ability of the jets to out-maneuver some high altitude SAMs is not an inherent capability in the V-22. This problem will be further discussed in the escort portion of this section. In any case, it is assumed for this type of tactic to be used, the high and mid altitude radar guided threat SAM threat has been identified and reduced.

Shaping and Zone Preparation. Shaping in this case would involve a deception plan along with whatever additional reduction of SAM assets might be required. The Zone preparation, provided adequate IPB and reconnaissance have taken place, should be minimal. Any zone preparation, due to the distance from indirect fire support assets, would have to be accomplished by fixed wing assets (The use of TLAM Tomahawk missiles or future shipboard ATACMS or equivalent might be possible, dependent on the priority of the mission). FSCAM (Family of Scatterable Mines) might be used to deny avenues of approach or insure the security of the zone through application to the perimeter. This might involve delayed automatic detonation to allow for friendly trafficability on the avenue after insertion. In any case, the

shaping and preparation requirements and timing would be dependent on METT-T-SL.

Conduct of the Flight. The flight of V-22s would take off from the LHDs/LHAs and displace at low level to provide for security of the ARG. This displacement before climb to altitude would be used to deceive any threat radars as to the position of the ARG. The V-22s range capability would allow for separate flights to displace to different areas, possibly giving the impression of more than one ARG. An appropriate number of the V-22s would be assigned an attached escort role and be armed with rockets and an increased number of expendables. The separate flights of V-22s would accomplish a climb to the appropriate threat avoidance altitude up to 20,000ft. At altitude, they could be preceded by F/A-18 aircraft flights (preemptive sweep escort) from the CVBG with a combination of air-air and air to surface (HARM) missiles. Dependent again on METT-T-SL, the flight might be preceded by AV-8Bs, the point is that a preemptive sweep escort is probably necessary. The support of an EA-6B would be important to either electronically reduce the enemy's radar capabilities or provide early warning of threat systems that may pose a problem to the transport aircraft.

The use of flights separated horizontally or one large flight would also be situationally dependent. Separation of flights would be necessary without the support of jamming capabilities of the EA-6B, but this would probably require a greater number of preemptive sweep escort aircraft for appropriate response to threats that might be separated horizontally. Separation of flights would deceive the enemy as to the flights termination point until the last possible minute.

Upon reaching the penetration point, located at the top of the penetration zone, the preemptive sweep escort would either penetrate to prepare the LZ or remain at altitude. In preparing the LZ, the escorts or additional attack aircraft would possibly use FAE to preclude cratering of HE munitions or the fratricide potential of CBU's. The penetration zone itself could be prepared by radar jamming by the EA-6B, chaff from the EA-6B and additional chaff from the escort V-22s.

The escort V-22 would penetrate first, again rotating helicopter tactics ninety degrees as

in the "dash" ahead. The method for penetration would require some development. It would be preferable for the descent to provide for a minimum of horizontal displacement to limit the size of the penetration zone and thus the IPB, reconnaissance, and preparation necessary. The V-22 NATOPS manual describes an emergency descent procedure that is essentially a helicopter mode, power off, full aft nacelle autorotation where rates of descent are approximately 3,000 to 4,000 feet per minute. Recovery is begun at 2,000ft AGL.⁸¹ The V-22 also demonstrates very benign stall characteristics that exhibit extremely high rates of descent. The recovery from this stall is also benign. A positive attribute of power off descent is a decrease of the IR signature.

The attached escorts, at the bottom of the penetration zone, would take up a traditional attached escort profile. There may be a need, for protection or deception, to have the V-22s again displace at low altitude at the bottom of the zone. This portion of the flight might be completed in the helicopter mode at TERF altitudes. The aircraft, METT-T-SL dependent again, would either conduct the insert as a large flight or by sections. The use of Fast Rope insert might be preferable. Upon egress, the transports and escorts might again displace as sections through separate routes before climb out for return to the ship. The aircraft may at this time be more capable of maneuver due to reduced weight. Their climb out might be by the original penetration zone, another penetration zone or the tactic may be to maintain a low-level profile until out of threat range.

Another note about Night Operations. Night operations or operations through an overcast would be the preferred climate for high altitude tactics. These tactics could also provide much utility for daytime operations. If conducted through an overcast layer, there may be a need for a reconnaissance initial terminal guidance team somewhere near the zone, not so much for terminal guidance as for ceiling and visibility reporting. The precise navigation capabilities of the V-22 should be able to get it to the zone.

The positives involved in this type of insert over the traditional low level type of insert are:

A reduction in obstacles

- better communications
- less crewmember and passenger fatigue
- reduced aural signature
- decreased chance of contamination in CBR environment
- increased pilot and crew situational awareness
- reduced exposure to the threat
- reduced visual signature

Figure 6-1 provides somewhat of a graphic depiction of the high altitude tactics.

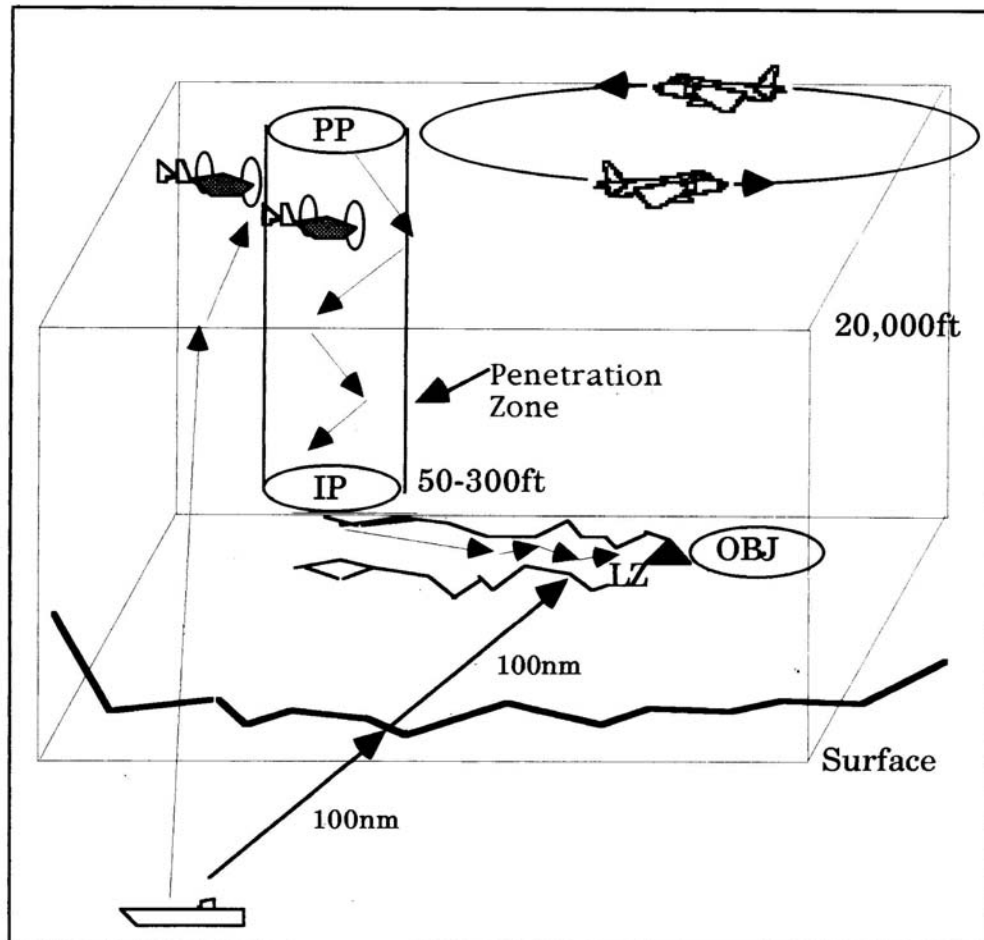


Figure 6-1
High Altitude Tactics (Penetration)

Low Altitude Tactics. The JMVX ORD requires the V-22 to be capable of precise navigation by a digital map and Global Positioning System with Light-weight Inertial Navigation System. The Ground Combat Element normally desires a rapid combat buildup in landing zones. The use of large formations of V-22's would inhibit maneuver, speed and threat avoidance

capabilities. The most survivable aircraft formation is the section for reasons of mutual supportability, maneuver and reduced signature. The low altitude tactics proposed by this section are based upon this factor, as well as the fact that the V-22 is more survivable at higher airspeeds. It is more survivable at higher airspeeds due to the limited exposure, reduced aural signature and evasion capabilities complimented by the speed.

Proposed Procedure. The tactic here is as mentioned earlier; Sections through separate routes to rejoin at an Initial Point for transit to the LZ. This tactic is supportable by the 4BW in the detached escort mode. The use of the 4BW as modeled in the 4BW/4BN Quicklook assessment is the most feasible way to escort the V-22 when flown in the low altitude regime. Additionally, attached escort of the 4BW to the flight of V-22s from the IP to the LZ is necessary. All the attributes of the IPB, reconnaissance, and shaping/preparation essential to high altitude tactics will provide benefits to the low altitude tactic.

Enroute Procedure. The flight of V-22s would break into sections of aircraft with detached escort provided by 4BW's and USMC fixed wing aircraft. The 4BW's would initially provide for preemptive sweep escort on the low level corridors. They would have to depart well before the V-22s to be in position for their arrival. Their mission would be essentially the same as the fixed wing MIG sweep in the high altitude tactics, except they would be concerned with surface threats to the V-22. The fixed wing detached escort would be necessary to provide threat suppression where the Cobras might not be able to respond quickly enough. The Cobras as well as the fixed wing escort would rely on "bull's eye" procedures for response to calls for fire from the V-22. The sections, if aggressed, would make the call for fire while scattering and crossing over to another pre-planned route (essentially a cross-mobility corridor).

After the flight join-up at the IP, the V-22s would convert to the helicopter mode of flight and the 4BW's would dash ahead to prepare the LZ. The detached fixed wing assets could also be used for LZ preparation.

The tactics described above would only be possible on the shorter range inserts required

of the V-22. A graphic depiction of low level tactics is provided in figure 6-2.

Additional Tactical Advancements

In Chapter 3, it was discussed that the Marines in Korea used the H-19 helicopter for the evaluation of a new procedure called "hit an' git."⁸² This procedure involved the ferrying a rocket launcher and its crew to a firing position, landing and firing a few rounds at an enemy position. The H-19 would then displace the rocket launcher to another position and fire again. This procedure has much tactical validity today.⁸³

The MLRS (Multiple Rocket Launch System) is being placed, in the form of a "four-pack," on a LAV (Light Armored Vehicle). The capability exists to produce a trailered version of this rocket system (a twin-pack) which would fit into the cabin area of the V-22. The 40km range of the basic MLRS rocket

could then be increased to that plus the V-22 that inserts it. This increase in range to almost the aft sponson fuel tank in with the future ATACMS much as 63 mm in this be increased even more if capability of the V-22 was the Artillery raid deserves exploration. If the produce one that will fit CH-53E should be

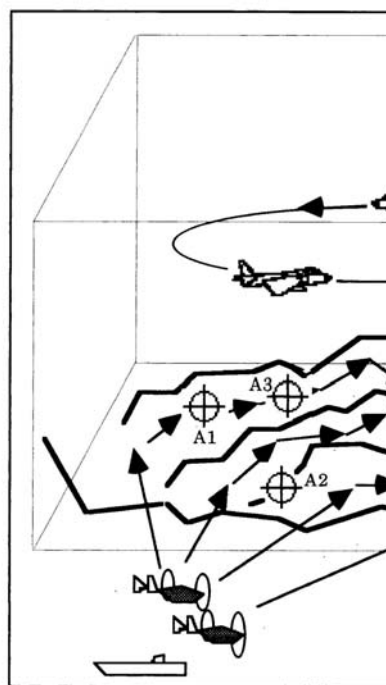


Figure 6-2
Low Altitude Tactics (section 6-2)

mission radius of the would mean an 300mn, 370nm with the V-22. The range missile might be as case. The range could the Aerial Refueling used. This variation of some further contractor cannot into a V-22, then the explored. A raid

provides results that are far out of proportion to the size of the force. The lost art of the heliborne

artillery raid is still a viable tactic with ever increasing capabilities.

Conclusion

There are some tactical solutions to the V-22 escort problem. The lack of an escort capable of providing attached escort for the V-22 could drive the more effective employment of aircraft in sections by separate routes. The capabilities of the V-22 in range, speed and altitude should be used to "exploit gaps." The V-22 should not have to be flown like a helicopter. High altitude tactics might have a peacetime effect on potential adversaries to the United States in littoral areas. Coastal defenses in littoral are not sufficient in themselves to protect from the movement of combat power ashore. The requirement of potential adversaries to defend against this tactic might be cost prohibitive to them.

CHAPTER 7: COUNTER-ARGUMENT

The biggest counter-argument to the arming of the V-22 with rockets would be the increase in the drag on the aircraft. This needs to be looked at. It must be kept in mind also that the V-22 is forecast to surpass all of its measures of effectiveness regarding airspeed. There should be no argument against an increase of the number of expendables on the aircraft. There has always been an argument that the helicopters in the USMC, which carry the same number of expendables forecast for the V-22, have carried too little. These helicopters will cover only half of the territory of the V-22 on a given mission. Consideration should be given to in-flight reloading of expendables from the cabin area.

The major counter-argument to all of this is that we should not have to adapt tactics to cover a deficiency in our capabilities. The problem lies in the potential of the public to support military expenditures. The public will not support wars that account for the lives of a great number of their sons and daughters. The need to fight wars of maneuver rather than wars of attrition is what has driven the acquisition of the V-22 in the first place. For the time being, the V-22 is going to have to be enough. It will be necessary for some tactical imagination to be used to make up for material deficiencies in the escort of the medium lift assault support transport mission.

CHAPTER 8: FURTHER RESEARCH REQUIREMENTS

Updated Studies and Analysis

Modeling and Simulation of the V-22 in the high altitude and penetration modes of flight needs to be accomplished to attempt to determine the necessary battlespace shaping for safe flight in these profiles. War gaming should then be accomplished to attempt to determine if this high altitude tactic has potential. The potential to provide portable oxygen systems to passengers and the sustainability factors involved in this need to be looked at. Additionally, the capability of arming the V-22 with rockets needs to be given a close look.

Developmental/Operational Test Requirements

If there are utilities found in any of this, then the TTPs developed from this should be incorporated in future testing for on aircraft validation.

CHAPTER 9: CONCLUSION

What's the BOTTOM LINE?

The V-22 does not necessarily require a "compatible" escort platform provided that tactics, techniques and procedures are developed and used to limit exposure to threat systems. If unanticipated exposure to threat systems occurs, the V-22 needs to possess adequate suppressive firepower to allow for execution of pre-briefed scatter plans. The use of the V-22 as an escort can solve some of the attached escort problem, provided it is used exclusively for escort on that mission. For this mission, the V-22 needs to be adequately armed, possibly with rockets and definitely with increased countermeasures expendables. Acquisition of portable passenger oxygen systems is necessary for the application of high altitude threat avoidance tactics.

¹Headquarters USMC, *Initial Deployment/Employment Concept For The MV-22 Osprey During The Period 1995-2015 (Draft)*, (Osprey Study) Study, 7 April 1986, F-6

²This review was attached to the Osprey Study.

³Headquarters United States Marine Corps, *Joint Multimission Aircraft Operational Requirements Document*, (Aviation Requirements: Quantico, VA, 1995) 2.

⁴CDR Bob Vernon, V-22 Test Plan Working Group of 1 December 1994.

⁵Carl Von Clausewitz, *On War*, (Princeton University Press: Princeton, New Jersey, 1984) 96-97.

⁶Ibid 170.

⁷Ibid.

⁸Ibid.

⁹Howard A. Wheeler, *Attack Helicopters, A History of Rotary-Wing Combat Aircraft*, (The National Aviation Publishing Company of America: Baltimore, MD, 1987) 66.

¹⁰Ibid. 49.

¹¹Ibid. 61.

¹²Ibid.

¹³Ibid 62.

¹⁴Shelby L. Stanton, *Vietnam Order of Battle*, (Galahad Books: New York, NY, 1987) 48.

¹⁵*The Vietnam War, Volume 3*, (The Marshall Cavendish Corporation: Long Island, NY, 1983)

26.

¹⁶Ibid.

¹⁷Ibid.

¹⁸Howard A. Wheeler, *Attack Helicopters, A History of Rotary-Wing Combat Aircraft*, (The National Aviation Publishing Company of America: Baltimore, MD, 1987) 35.

¹⁹Ibid.

²⁰Ibid. 66.

²¹Ibid

²²Peter V. Mersky, *U.S. Marine Corps Aviation, 1912 to the present* (The National Aviation Publishing Company of America: Baltimore, MD, 1983) 242.

²³METT-T-SL denotes mission planning using an analysis of mission, enemy capabilities, friendly troops, terrain and weather, time, space, and logistics.

²⁴Naval Warfare Publication (NWP) 55-9-ASH, *Assault Support Helicopter Tactical Manual*, Washington, DC: Department of the Navy, March 1992), 15-1

²⁵Ibid 15-2

²⁶Ibid 15-3

²⁷Howard A. Wheeler, *Attack Helicopters, A History of Rotary-Wing Combat Aircraft*, (The National Aviation Publishing Company of America: Baltimore, MD, 1987) 36-37.

²⁸*The Vietnam War, Volume 3*, (The Marshall Cavendish Corporation: Long Island, NY, 1983) 50.

²⁹Major Mark Clark, former MH-53J USAF exchange pilot, interview by author, 7 March 1996.

³⁰*Jane's all the Worlds Aircraft 994-1995*, (Jane's, Surry, UK, 1994) 537.

³¹Major Mark Clark, former MH-53J USAF exchange pilot, interview by author, 7 March 1996.

³²Howard A. Wheeler, *Attack Helicopters, A History of Rotary-Wing Combat Aircraft*, (The National Aviation Publishing Company of America: Baltimore, MD, 1987) 52.

³³Vladislav Tamarov, *Afghanistan - Soviet Vietnam*, (Mercury House: San Francisco, CA) 21.

³⁴David C. Isby, *War in a Distant Country Afghanistan: Invasion and Resistance*, (Arms and Armour Press, Artillery House, Artillery Row: London, UK. 1989) 64.

³⁵Ibid. 59.

³⁶Howard A. Wheeler, *Attack Helicopters, A History of Rotary-Wing Combat Aircraft*, (The National Aviation Publishing Company of America Baltimore, MD, 1987) 52.

³⁷Headquarters United States Marine Corps, *Joint Multimission Aircraft Operational Requirements Document*, (Aviation Requirements: Quantico, VA, 1995)

³⁸Headquarters United States Marine Corps, *Operational Maneuver From the Sea*, FMFRP 14-21 Coordinating Draft, 31 March 1995, 10.

³⁹Ibid.

⁴⁰Ibid.

⁴¹Harry Franks, Lecture presented at the Marine Corps Intelligence Activity, for the Intelligence for the Commander Course, 4 March 95.

⁴²Headquarters United States Marine Corps, *V-22 EMD Mission Effectiveness Analyses (MEA) (Interim Draft) Mission/Scenario Identification and Selection Report*, Volume II, The Iranian Scenario, June 10, 1993, 3B-21.

⁴³Harry Franks, Lecture presented at the Marine Corps Intelligence Activity, for the Intelligence for the Commander Course, 4 March 95.

⁴⁴Ibid.

⁴⁵Robert Steele, Lecture presented at the Marine Corps Intelligence Activity, for the Intelligence for the Commander Course, 4 March 95.

⁴⁶This NAWC, China Lake study was completed but never published. Portions of that study were used by Operational test personnel for V-22 Operational Assessment OT-IIA and, as such, are familiar to the author who participated in this assessment.

⁴⁷COMOPTEVFOR ltr 3980 (M960-OT-IIA) Ser 53/0958 of 17 Aug 1994,4-45.

⁴⁸Ibid.

⁴⁹Center for Naval Analysis, *Susceptibility Reduction Through Terrain Masking and Airspeed*, Study, CRM 92-64, July 1992

⁵⁰Ibid. V.

⁵¹COMOPTEVFOR ltr 3980 (M960-OT-IIA) Ser 53/0958 of 17 Aug 1994,4-45.

⁵²This NAWC, China Lake study was completed but never published. Portions of that study were used by Operational test personnel for V-22 Operational Assessment OT-IIA and, as such, are familiar to the author who participated in this assessment.

⁵³COMOPTEVFOR ltr 3980 (M960-OT-IIA) Ser 53/0958 of 17 Aug 1994,4-45.

⁵⁴Ibid. 4-47.

⁵⁵Ibid.

⁵⁶COMOPTEVFOR ltr 3980 (M960-OT-IIB) Ser 157/047 of 22 Jan 1996,4-53.

⁵⁷COMOPTEVFOR ltr 3980 (M960-OT-IIA) Ser 53/0958 of 17 Aug 1994,4-47.

⁵⁸COMOPTEVFOR ltr 3980 (M960-OT-IIB) Ser 157/047 of 22 Jan 1996,4-42.

⁵⁹Ibid. 4-43.

⁶⁰Ibid 4-45-4-46.

⁶¹John Everett-Heath, *Design, Development and Tactics, Soviet Helicopters*, (Jane's Publishing Company Limited: London, UK, 1983)124.

⁶²Howard A. Wheeler, *Attack Helicopters, A History of Rotary-Wing Combat Aircraft*, (The National Aviation Publishing Company of America: Baltimore, MD, 1987) 36-37.

⁶³Ibid 37.

⁶⁴Headquarters United States Marine Corps, *Joint Multimission Aircraft Operational Requirements Document*, (Aviation Requirements: Quantico, VA, 1995)10.

⁶⁵Ibid 3.

⁶⁶COMOPTEVFOR ltr 3980 (M960-OT-IIB) Ser 157/047 of 22 Jan 1996,4-48.

⁶⁷John Everett-Heath, *Design, Development and Tactics Soviet Helicopters*, (Jane's Publishing Co. Ltd: London, UK, 1983) 133.

⁶⁸Headquarters United States Marine Corps, *Joint Multimission Aircraft Operational Requirements Document*, (Aviation Requirements: Quantico, VA, 1995) 2.

⁶⁹Ibid 4.

⁷⁰Marine Corps Combat Development Command, *AH-1 W/4BN and UH-1N/4BN Quick Look Operational Effectiveness Analysis*, Study, 28 April 1995,5.

⁷¹These ambient conditions are realistic to the littoral environment.

⁷²Marine Corps Combat Development Command, *AH-1 W/4BN and UH-1N/4BN Quick Look Operational Effectiveness Analysis*, Study, 28 April 1995,23.

⁷³These values were taken from the 4BW/4BN Quicklook assessment and the V-22 OT-IIB Test Report.

⁷⁴This value is with only feed tanks and forward sponson tanks on the V-22. With one aft sponson tank filled, the radius increases to 33 mm.

⁷⁵Headquarters United States Marine Corps, *Joint Multimission Aircraft Operational Requirements Document*, (Aviation Requirements: Quantico, VA, 1995) 28.

⁷⁶In a study conducted for PMA-205, the V-22 operational test team concluded that the V-22 would be flown in the airplane mode of flight at least 70 percent of the time for the typical Marine utilization.

⁷⁷COMOPTEVFOR ltr 3980 (M960-OT-IIB) Ser 157/047 of 22 Jan 1996,4-48.

⁷⁸Cdr Tom Curtis, AIR 5115X, *V-22 Briefing For Multi-Service Operational Test Team*, 6 May 1994.

⁷⁹Robert Steele, Lecture presented at the Marine Corps Intelligence Activity for the Intelligence for the Commander Course, 4 March 95.

⁸⁰Headquarters United States Marine Corps, *Joint Multimission Aircraft Operational Requirements Document*, (Aviation Requirements: Quantico, VA, 1995) 14.

⁸¹A1-V22AA-NFM-00, NATOPS Plight Manual, Model MV-22A Aircraft, 14 May 92, III-7-21.

⁸²Howard A. Wheeler, *Attack Helicopters, A History of Rotary-Wing Combat Aircraft*, (The National Aviation Publishing Company of America: Baltimore, MD, 1987) 35.

⁸³Ibid. 35.

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